

APPENDIX B

REFINERY OUTAGES AND PROCESS UNITS

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Regular maintenance of refinery process units is necessary to maintain yields and reduce the risk of catastrophic failures. Refineries with enough complexity to produce large volumes of gasoline, diesel, and jet fuel are made up of many units; however, the units which appear to affect production the most are crude units, fluid catalytic cracking units (FCC units), hydrocracking units (hydrocrackers) and diesel hydrotreaters.

This analysis focuses on these units and attempts to determine if there are any seasonal patterns for maintenance events. It describes how production may be affected when a unit is undergoing maintenance or repair.

Table B-1 illustrates the severe conditions under which these units operate.ⁱ

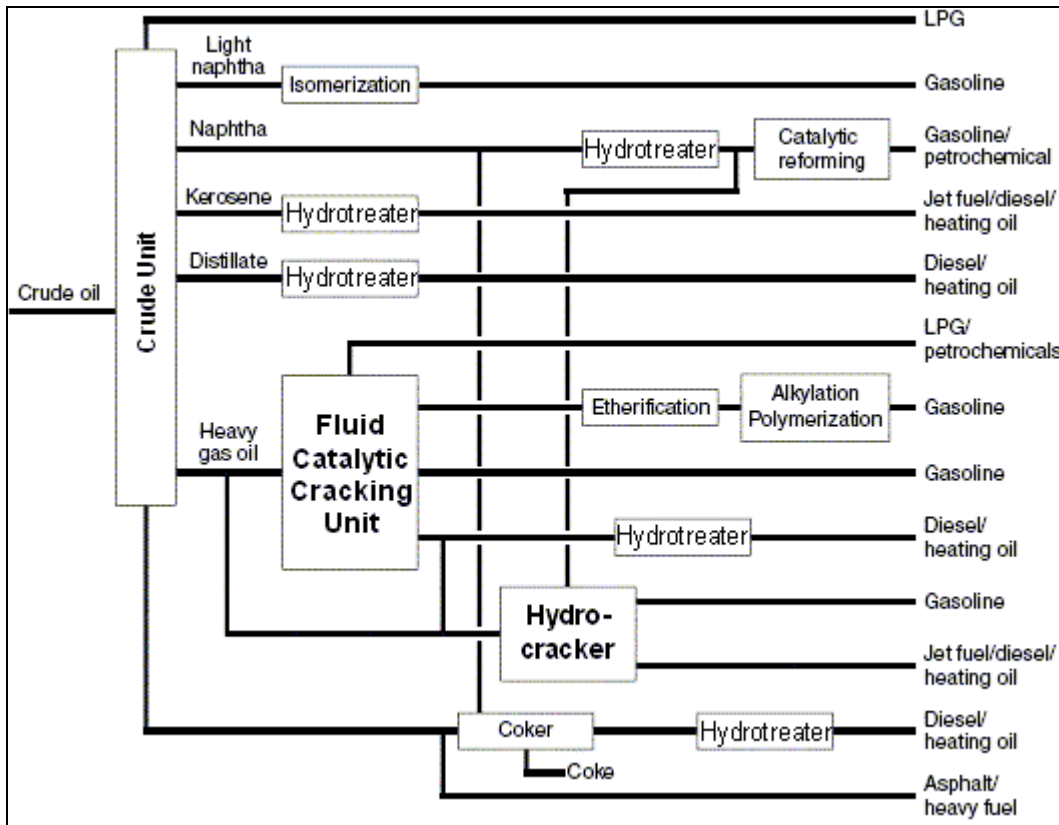
Table B-1: Process Unit Operating Conditions

Unit	Operating Temperature	Operating Pressure
Crude Unit	650° to 700° F	Slightly above atmospheric pressure
FCC Unit	750°-1500° F	1,000-2,000 psi
Diesel Hydrotreater	600° to 800° F	1,000 psi
Hydrocracker	750°-1500° F	1,000-2,000 psi

In a crude unit, heat is applied to crude oil to separate the oil into various components which are then sent to other refinery process units. FCC units process feedstock in the presence of a catalyst at high pressure and temperature. Hot catalyst in the FCC unit reacts with the feedstock to “crack,” or break apart, large molecules into smaller molecules in the range of gasoline and diesel fuels. Hydrocracking units operate similarly, but hydrogen is fed into the reactor during operation. Diesel hydrotreaters remove sulfur, nitrogen, and metals by passing the feedstock through a catalyst in the presence of hydrogen.

Figure B-1 illustrates how refinery units are interconnected.ⁱⁱ

Figure B-1



For this analysis, an “outage event” is defined as an individual refinery processing unit that is shut down or operated at significantly reduced rates due to either planned or unplanned circumstances, typically for maintenance or repair. The Energy Commission has compiled information on refinery outage events since July 2004. Refinery outage information is either reported by the industry or determined by staff investigations of published news reports or changes in refinery inputs and production.

Table B-2 shows the number of events included in this analysis for each type of processing unit for both planned and unplanned events. The data is based on the state’s 14 gasoline and diesel producing refineries. Refineries that do not produce gasoline or diesel fuel are not included in the analysis.

**Table B-2: Observed California Refinery Outage Events
January 2005 through June 2006**

Event Type	Planned	Unplanned	Total
Crude Unit	10	5	15
FCC Unit	8	9	17
Diesel Hydrotreater	6	6	12
Hydrocracker	6	5	11

Effects of Maintenance on Production

Crude Processing Unit

Unplanned maintenance on crude processing units has a very dramatic impact on production compared to other refinery unit outages. On average, crude oil inputs during an unplanned maintenance event decline by 39 percent. With reduced inputs of crude oil, other refinery units are either shut down or run at reduced rates. During either planned or unplanned crude processing unit events, refiners may purchase intermediate productsⁱⁱⁱ on the open market or use existing inventories in order to maintain production of finished products.

Table B-3 shows the average percentage of reduced production of finished products and crude oil inputs for 15 maintenance events involving crude units between January 2005 and June 2006. Unplanned crude unit events have a significantly greater impact on production compared to planned maintenance events.

**Table B-3: Crude Processing Unit Maintenance Events
January 2005 through June 2006**

Average Percentage Effect on Production and Oil Inputs			
Type of product/input:	Planned events	Unplanned events	All events
Gasoline Production	-9%	-18%	-12%
Diesel Production	-14%	-50%	-28%
Jet Fuel Production	-21%	-48%	-31%
Oil Input	-26%	-39%	-31%

Fluid Catalytic Cracking Units

Fluid catalytic cracking (FCC) units experience more maintenance events than any other refinery processing unit during the period from January 2005 through June 2006. These maintenance events significantly affect gasoline production more than diesel or jet fuel production.

Table B-4 shows the average percentage of reduced production of finished products and crude oil inputs for 17 maintenance events involving FCC units between January 2005 and June 2006.

**Table B-4: FCC Unit Maintenance Events
January 2005 through June 2006**

Average Percentage Effect on Production and Oil Inputs			
Type of product/input:	Planned events	Unplanned events	All events
Gasoline Production	-22%	-33%	-28%
Diesel Production	1%	-20%	-10%
Jet Fuel Production	-9%	-12%	-11%
Oil Input	-3%	-4%	-4%

Diesel Hydrotreater

Maintenance on diesel hydrotreaters largely impacts diesel fuel production. During some diesel hydrotreater maintenance events, refineries have been observed to increase production of jet fuel for periods where diesel hydrotreaters are shut down. Jet fuel is a distillate similar to diesel fuel but with a less stringent sulfur specification (1,000-3,000 parts per million [ppm]) compared to the current maximum limit of 15 ppm sulfur for on-road diesel fuel in California.

In June of 2006, California refineries were required to begin producing an ultra-low sulfur diesel fuel with a maximum sulfur content of 15 ppm. Many refineries have had to upgrade their diesel hydrotreaters in order to meet the new specification. Most of this maintenance took place in late 2005 and early 2006.

Table B-5 shows the average percentage of reduced production of finished products and crude oil inputs for 12 maintenance events involving diesel hydrotreaters between January 2005 and June 2006.

**Table B-5: Diesel Hydrotreater Maintenance Events
January 2005 through March 2006**

Average Percentage Effect on Production and Oil Inputs			
Type of product/input:	Planned events	Unplanned events	All Events
Gasoline Production	-20%	-21%	-20%
Diesel Production	-35%	-40%	-37%
Jet Fuel Production	0%	-37%	-15%
Oil Input	-9%	-2%	-6%

Hydrocracker Maintenance

Typically, a refinery will use a hydrocracker to produce diesel and jet fuels.

Table B-6 shows the average percentage of reduced production of finished products and crude oil inputs for 11 maintenance events involving hydrocrackers between January 2005 and March 2006^{iv} (the affect on jet fuel production is not included due to confidentiality).

**Table B-6: Hydrocracker Maintenance Events
January 2005 through March 2006**

Average Percentage Effect on Production and Oil Inputs			
Type of product/input:	Planned events	Unplanned events	All Events
Gasoline Production	-17%	-13%	-16%
Diesel Production	-30%	-25%	-28%
Oil Input	-9%	-2%	-6%

Next Steps

The Fossil Fuels Office will continue to analyze and collect refinery outage information. As more data is collected, additional information about common refinery process unit outages will become available. Specifically, effects on refinery production during maintenance events involving coking units, reformer units, and several types of hydrotreaters other than diesel hydrotreaters would provide a more complete understanding of the effects of maintenance on production.

Endnotes

ⁱ Operational Safety and Health Administration Technical Manual Section IV Chapter 2. [http://www.osha.gov/dts/osta/otm/otm_iv/otm_iv_2.html].

ⁱⁱ Adapted from *New Forces at Work in Refining: Industry Views of Critical Business and Operations Trends*. D.J. Peterson, Sergej Mahnovski.

ⁱⁱⁱ Oils that have been partially processed into “fractions” which can be used as feedstock for refinery units downstream of the crude unit.

^{iv} The Petroleum Industry Information Reporting Act (PIIRA) requires that company specific data be held in confidence. Jet fuel is not included in Table B-6 because there were an insufficient number of events to aggregate production data for publication.